Man, Culture and Biodiversity

Understanding Interdependencies

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Edited by

Gertrude Hauser
University of Vienna, Vienna, Austria

Michael A. Little
Binghampton University, New York, USA

and

Derek F. Roberts
University of Newcastle upon Tyne, UK

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Traditional Prehispanic Ecotechnologies for the Management of Biodiversity in Latin America

by

M. Monasterio

In Latin America the pre-Hispanic cultures managed complex ecotechnological systems which through an extended historical process of cultural adaptation reached a surprising degree of stability. Examples, are the elaborate agrarian systems that evolved in the Mesoamerican and Andean highlands; the grazing systems involving native *Camelidae* in the Punas; the quite complex lacustrine agricultural systems of the Mexican "Chinampas"; the Zenú hydraulic society in the Caribbean lowlands of Colombia. Moreover, in the shifting cultivation systems in the tropical rainforest regions, cycles of utilisation and succession-regeneration allowed the maintenance of the forest ecosystems (Amazonia, Lacandona Maya forest in México and Guatemala, etc.).

In many cases the diverse cultures produced "surpluses" recognised as heritages of great value for humanity, for they were manifested in architectural monuments, works of art, feats of engineering, technological inventions, and scientific creativity; in this last case affecting through ecotechnological processes the management of biodiversity, biotechnology, genetic improvement and the regeneration of the ecosystems. Today this knowledge persists in the indigenous peasant communities where however it has been integrated through the process of cultural mixture.

This discussion will show the importance of a fundamental investigation which will lead us to understand, rescue and revalue the complex processes involved in the traditional systems, and to transfer them to the management of biodiversity for sustainable development, thereby enriching the development of the present ecotechnology.

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Biological and Cultural Diversity

The meeting of Rio-92 showed that on a world scale biodiversity is not only of biological concern, a problem which can be tackled with the tools of the natural sciences, but that it has unsuspected socio-economic and cultural connotations, which relate to the past, present and future of humanity. The maintenance, and even the possible enrichment, of biodiversity is a process opposed to the modern tendency to simplify natural systems. To understand this process it is necessary to take into account the development of pre-Hispanic cultures, colonial models and the homogenising Western culture which prevails today.

The total territory of Latin America, supracontinental in scale, contains the greatest ecological and biological diversity of the planet, mainly concentrated in the vast inter-tropical regions. In the plains, large areas occupied by forests, woods, savannas, wetlands and deserts are juxtaposed, and these contain an immense biological diversity, constituting potential strategic resources. Many of these have only recently begun to be recognised by the dominant culture, but have been used and managed by the indigenous cultures during a long historical process of adaptation to and interaction with the environment.

Likewise the tropical and subtropical mountains of the Americas include the greatest biological and cultural diversity to be found in any mountain system. This mountain system stretches from the subtropical Andes (north of Argentina-Chile) to the subtropical mountains and high plateaux of México, forming a continuous backbone in the three Americas. Similarly there is lengthwise diversity in the altitudinal gradients, which give rise to ecological zonation and thus to differences in the use of the land and the human occupation over short distances.

The mountain zones, with their succession of high plateaux levels, were the seat of the great civilisations in America: the High Andean cultures in the Central Andes and the Mesoamerican cultures. The relationships between the natural biodiversity (genetic, population, species, ecosystem) and the cultural development which occurred in these zones are an outstanding model of cultural and environmental interaction.

One example of the scientific and technical evolution of these civilisations is provided in the complex and great richness of domestication of plants (Toledo et al., 1985; Solbrig and Solbrig, 1994). Maize and potato stand out amongst these plants which, through a long process of selection and genetic improvement, developed a huge variety of cultivars which acclimatised and adapted to a wide range of contrasting environments across the altitudinal and horizontal gradients. Another example worth mentioning is the domestication and genetic diversification of the camelids (llama, alpaca, vicuña) in the central Andes, a process which required complex techniques for the management of both the animal populations and the dynamics of the pasture grasses at high altitude.

In these cases the ecological diversity promoted the spread of the plant cultivars and animal populations and their adaptation to a diversity of agroecological and rangeland niches. This process of biodiversification would not have been possible in more homogeneous environments, such as those which characterise the temperate highlands.

In the marshy tablelands of Mesoamerica another example is the "Chinampas" agriculture (Toledo et al., 1985) which, by taking advantage of the organic soils and the aquatic plants of the lakes, gave rise to one of the most original and productive ecological systems in the world. Coe (1964) and Venegas (1978), from ecological and agronomical studies, considered that this pre-Hispanic agroecosystem integrated the management of water, soil, solar energy, wild and cultivated plants, animals, manure etc. It achieved in small areas high levels of yield and diversification, being able to integrate agriculture, horticulture, fish-farming and today intensive cattle-farming.

In contrast to what has succeeded it, the indigenous experience must be reconsidered. It is necessary to re-evaluate the importance of lakes, temporary pools and other water bodies as the basis of efficient systems for sustainable development and intensive diversification of food production, as is the case in the "Chinampas", (Toledo et al., 1985).

Turning to the fourth example, the indigenous agroforestry management is perhaps the best-known: fallow-succession-regeneration of the tropical forest allowed the continuing co-existence of the population with the most diverse and structurally complex ecosystem of the planet. The capacity of the indigenous populations to utilise and manage their territories in the vast Amazonian areas, and in the lowlands of Mesoamerica (Central America and México), is the result of knowledge and understanding transmitted from generation to generation. No later model of rainforest management, in the Americas, has been capable of utilising the resources, recognising the potential uses, and transforming them to satisfy subsistence, magic, ritual and other cultural needs.

With respect to the pre-Hispanic civilising processes, the 16th century brought a disruption in the prevailing cultural and agroecological developments in the Americas and, in our particular case, in the management of biodiversity.

Five hundred years ago Europe did not have technological models for the management of the vast land, sea, coastal and island areas of the tropical and subtropical regions of the American continents. The West did not have solutions to the basic problems that faced it in devising economic and social measures which would lead to the harmonious development of its colonies. It did not have the technical resources or the economic strategies adequate to cope with the tropical forest or the high Andean plateaux, which presented conditions not previously encountered. Therefore the West left vast areas which were almost impenetrable and above all unmanageable: the tropical forests, the Andean plateaux and the deserts. These areas became refuge zones for the indigenous populations and high diversity was maintained there.

The independence and the development of new republics brought still more westernisation in the name of progress. Today's so-called ecological crisis and the biotechnological potential contained in the American tropics offer an incipient space to draw together and re-evaluate the reserve of knowledge of the indigenous and peasant populations of America that still remains. As a basic premise it is necessary to evaluate economically that knowledge, incorporating it in their capacity for self-management. For sustainable development it is necessary to rescue scientifically their agroecological practices and to know the biological processes involved in their systems of production.

Figure 1 summarises our approach in this research. The American pre-Hispanic societies (top left) contributed to a rich technological heritage through the invention of agriculture, its adaptation to a wide variety of natural environments, domestication of many plant and animal species, invention of an irrigation technology with quite elaborate engineering works, development of original technologies for food conservation. On the right side, from 1492 onwards, many mestizo cultures arose from the cultural hybridisation of aboriginal and mediterranean traditions, incorporating new crops, animals, tools and agricultural practices.

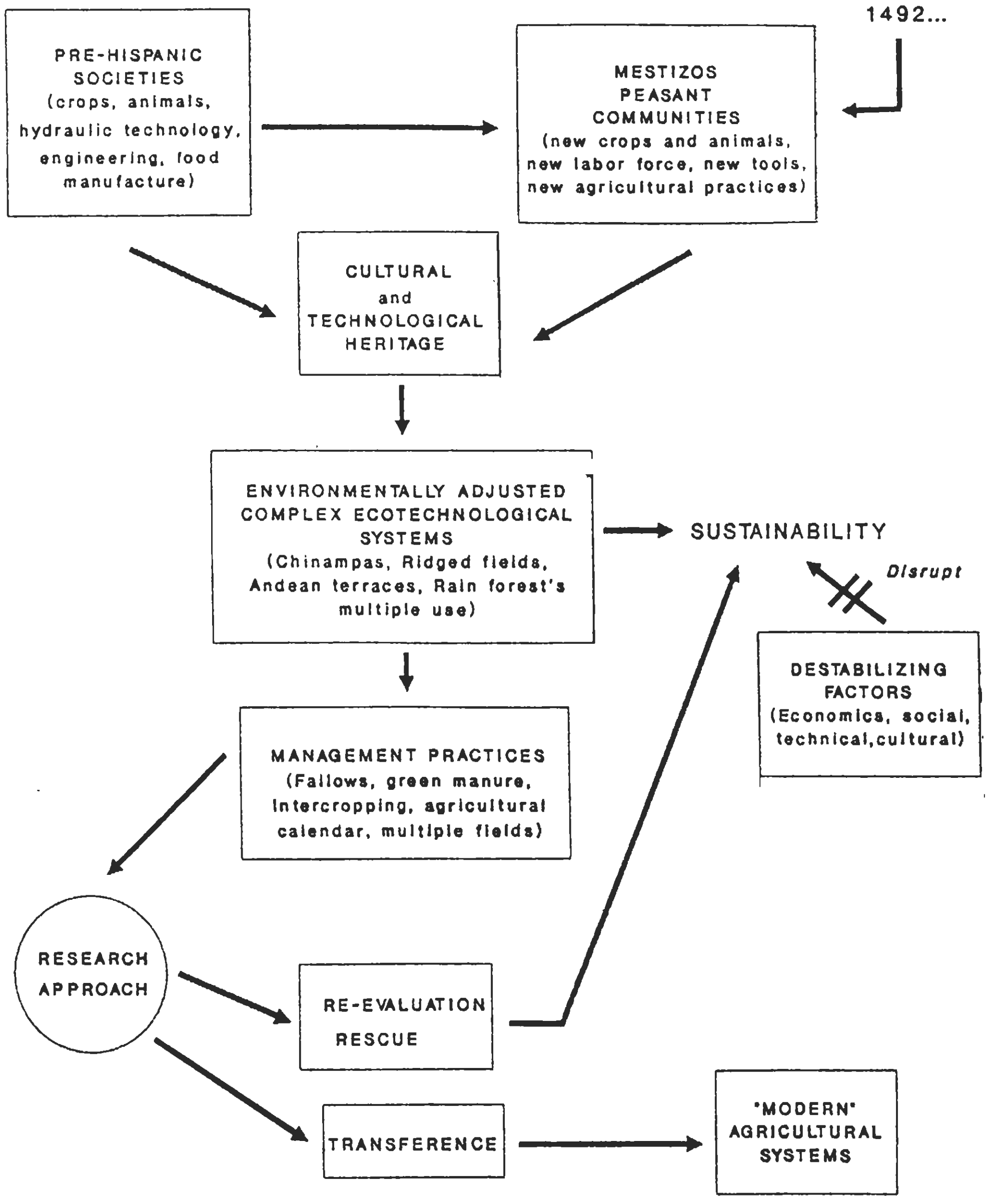

Figure 1. **Re-evaluating traditional prehispanic ecotechnologies for the management of biodiversity in Latin America.**

This cultural heritage, either pre-Hispanic or mestizo, gradually gave rise to complex ecotechnological systems, adjusted to different environments, such as the Chinampas of the valley of México, or the raised fields of the Caribbean lowlands, or some agriculture and pastoral systems in the Andes. These systems were sustainable under certain conditions, but destabilising factors acted upon them over 5 centuries of colonisation and formation of the Latin American national states.

Our approach to the traditional knowledge is centred on the management practices of the indigenous and peasant agricultural systems, the scientific analysis of each of the cultural practices, and rescue of those evidencing an ecological and socio-economic rationality. Eventually this knowledge may be transferred to the neighbouring "modern" agriculture. This approach is the opposite of the research philosophy aiming solely at a unidirectional technological transference from modern to traditional systems.

The Andes as a Management Model

Of the several pre-Hispanic systems briefly touched upon, the Andean can be taken as an example of management. Its apogee occurred in the central Andes from which it spread out to the northern and southern mountain ranges. Among its outstanding features were the territorial organisation, the complementary management of many contrasting environments, the hydraulic and soil conservation engineering works on a regional scale, the dense communication network, biotechnological inventions affecting management of resources, genetic diversification and the advancement of the limits of agriculture into the high Andean zones of recurrent frosts.

From this complex list the key points can be picked out for interpreting the strategies employed in the management of the diversity in the different zones of climate, place and time, and which were the basis of their functioning and development.

Territorial Organisation and Regional Planning

The strategy of ecological complementarity, that is to say, the simultaneous control by one group of people of diverse and separate territories located in different ecological areas, constituted one of the principal bases of the sustained development of the high Andean civilisations before the European conquest in 1532 (Murra, 1975). In this pattern of regional land use along altitudinal and hydrothermic gradients, called "complementarity in terrestrial archipelagoes" (Murra, 1985), the main centre of occupation, control of power and greatest human density was found in the high plateaux above an altitude of 3200m. This apparent paradox of intensive occupation of the high Andean plateaux in cold tropical environments, considered by Europeans unfavourable for human beings and the development of agriculture, is understandable because there was in fact a climate adequate to allow sustained development throughout thousands of years, which culminated in the formation of an empire. The Inca Empire was then later disrupted by European invasion. This central control of the diversity of territories is similar to that which evolved in other complex societies elsewhere which enabled the utilisation of multiple resources and the development of the social complexity.

This control exercised from the cold high plains, extended over occupation zones situated on both sides of the Andes, that is to say on the Western slopes down to the Pacific coast and on the Eastern slopes to the Amazonian borders. The extent of these zones was of great importance for they incorporated belts of transverse complementarity which succeeded each other throughout the length of the Central Andes (Murra, 1992). It was on the solidarity and control created by these interrelationships, that the social unification of the central Andes was mainly founded.

The capacity for environmental management of this culture was surprising; it allowed the exploitation of all the ecological levels from the highest peaks to the Pacific with its coastal and maritime potential in the West, and to the slopes which descend to the Amazonian forests on the East.

Thus, on to the integration achieved in the zones of transverse complementarity, managed from the highlands, was superimposed a process of superintegration in the longitudinal Andean axis, which allowed unification of the transverse zones which were relatively isolated ethnically, and totally isolated socio-politically. These ecological and socio-economic bases were the foundation for the constitution of the great political structures, Wari, Tiwanaku, which culminated in Tawantinsuyo, the Inca Empire.

Andean Agroecology

It was in these conditions of the high Puna plateaux, apparently unfavourable in European eyes, that the inhabitants of these cold tropics very early utilised the daily cycles of freezing and thawing to develop the technique of dehydration of tubers (chuñu) and of meat (ch'arki), (Troll, 1968), which allowed their storage for long periods of time. The massive storage of these key easily transportable foods was the basis for an important macro-economic development and not merely the generation and persistence of peasant societies (Murra, 1992).

The societies of the high Andes made use of the constant diurnal rhythms of the mountain tropics - night freezing and daytime thawing combined with high insolation - to create a complex technology of food preservation, the biochemical processes of which have still not been measured or interpreted by modern science.

In the contrasting rainfall conditions of the Puna, with cycles of rain and drought, the tubers only develop in the wet season of the year. The Andean societies found a method to preserve the tubers and reduce their weight, which is an additional advantage for their transport to other altitudinal levels of secondary occupation, or over the long distances travelled by the Inca armies which colonised and integrated the territories.

The manufacture of chuñu (using potatoes and other tubers) can be carried out in the open country. The tubers are spread out during the night on straw in small depressions in the surface of the soil, exposed to the night frost. In the morning they are soaked with running water. This process is repeated over several weeks. This great invention of using the diurnal microclimatic cycle of the tropical Andes was of enormous advantage in establishing human settlements at high altitudes, where many tubers are found and there are recurrent frosts.

Permanent settlements at high altitudes only became possible after the development of this process of food preservation. Formerly these were areas where tubers were only produced during the wet season (three to six months per year in the Punas). Another important advantage for settlements at high altitude was the presence of wild camelids in the pastures above the level of the Punas. Once domesticated, the application of the same principles and technical processes to the preservation of the meat brought enormous advantages, diversifying the diet and complementing its protein value.

In the total strategy of the Andes the notable points include: the capacity to utilise space and time variation to make use of the ecological and biological diversity; the management of multiple environments, with their annual precipitation cycles and daily microclimatic cycles, which enabled the development of techniques to preserve food. Another notable fact was the experimentation and genetic improvement which brought about the acclimatisation of Amazonian plants, such as coca, to the "Yungas" (wet valleys), and the adaptation of many potato varieties to altitudes over 4.000m. These potatoes were grown in the plots of the temporary residences of the puna shepherds who stayed at great heights during the season when the mountain ranges were snow-free and the pastures provided good feeding for their flocks.

We have not emphasised the hydraulic engineering works, such as dams and canals, nor the many anti-erosion techniques employed on the steep mountain slopes, such as the huge system of terraces which characterises the Andean mountains by their impressive appearance. It would take too long to detail all the infrastructure and the conservation practices which were elaborated for the control and management of water and soils. Here we have only given a brief idea of the aspects related to the utilisation of biodiversity and the sustained development, the combined organisation of space and time, and the political and ecological significance of land use. But it is important to stress the technological and biological innovations arising from the relationship between these human societies and nature, which allowed exploitation of raw materials in the high Andes, associated with a genetic diversification and a wider distribution of Andean tuber cultures to agro-ecological niches which are more extreme in temperature than those found in the intertropical zone.

The Current Situation

Following pressures exerted in the Andean region during the colonial and republican regimes that tore apart the Inca organisation, it is necessary to reflect on the present-day situation:

> What now remains of the complementary use of resources in the mountain ranges?
>
> What is left of the territorial planning of the pre-Colombian archipelagoes?

Today even though disorganised, in the schemes of the ancient archipelagoes adjustments have been made so that in many cases parts continue to be used of the complementarity of the diversity in the Pacific-Andean-Amazonian regions. There still persists in a large part of the indigenous societies and Andean peasantry a complementary localisation of their plots in different ecological areas, often at a distance of many days' walk from their principal high altitude residence.

There remain various examples of groups of people living at altitude who still utilise higher and lower levels, reaching them on foot. One of the most notable cases is that of the Q'ero indigenous communities (Flores et al., 1989) who control an altitudinal range of 4000m. This stretches from the level of the "Yungas" (wet valleys) at 1500m where they cultivate coca plants, fruit trees and now coffee; across the intermediate mountain levels where maize cultivation predominates and the high valleys with tuber cultures; to the high levels with pasture grasses and camelids over 5000m. Above these altitudes they still communally run the salt-mines.

In the situation found today, the complementarity of the agricultural cycles in the successive seasons of the year takes on a new fundamental importance, now that many areas are utilised by the same groups of people who journey from one ecological level to another during the year; this is the situation in the Q'ero indigenous farming people. Due to the extreme isolation and inaccessibility of the Q'ero, they have been able to resist the powerful pressures towards destroying the system of multiple use of gradients.

Ecological complementarity does not only persist in peasant communities, but also it is practised by owners of large "haciendas" who controlled, until quite recently, several altitudinal levels and utilised them for the production of potatoes, maize and the diverse products of the "Yungas" (Fioravanti, 1975).

The continuing presence of a dense human population in the tropical Andes from the northern to the central cordilleras (Monasterio, 1989; Morlon, 1992), is a fundamental historical fact, from the times of the local chieftains ("cacicazgos"), through the Inca Empire, the colonies and the current states. This human presence is linked to the existence of a peasantry with a strong social organisation and a profound environmental knowledge, constituting a strong mesh of forces which has resisted all the destabilising pressures and the large emigration to urban centres, and which has been maintained.

The density of the population permitted the construction and maintenance of a complex infrastructure of irrigation, soil conservation, management of the animal herds and pastures, and the accomplishment of the seasonal sequence of the agricultural tasks throughout the year.

What lessons can be learnt from today's peasant societies which preserve and practise the technical knowledge, carrying out the series of ecological and biological processes for utilisation of the environment yet modifying them to meet new situations. They also, unbiasedly absorb and adapt non-Andean technical elements whenever they consider it convenient and possible.

It is clearly of scientific and practical value, indeed of social, economic and political value as well, to recognise, re-evaluate, rescue and transfer all this information which still persists. Ecotechnology can play a role in the rescue and re-evaluation of traditional knowledge.

Ecotechnology, Sustainability and Equitability

What follows relates to ecotechnology, its conception and current application as used by research groups in Latin America who recognise its "traditional" origin, as a product of a long society/nature interaction. Ecotechnology may be defined as the combination of technologies which shape a system of utilisation adapted to the environmental ecological, social and cultural conditions in such a way as to satisfy the needs of a defined region and to allow the transfer of resources to areas of ecological and economic complementarity.

Ecotechnology is characterised by:

1. A holistic view of technology (including biotechnology) seen in an environmental context, cultural and ecological.

2. Technological or biotechnological solutions, or a combination of both, adapted to the management of open systems, partially self-regulated and in continual transformation, as are agro-ecosystems and natural ecosystems.

3. As a first priority, satisfaction of the needs of the local populations for resources, using optimal means of production compatible in the best possible way with the stability of their environment and sustainability of the production systems. Yet where control and self-management of key resources by local populations prevails, it is important also to be open to the requirements and needs of other regions and populations sharing the principle of global equality.

4. Selection of productive systems which minimise the ecological costs and maximise the conservation of natural resources (primary sources of production and transformation) through the understanding of the ecological processes which govern the functional dynamics, productivity transformation of the agro-ecosystems and surrounding natural ecosystems, with the objective of achieving sustainable development.

5. Evaluation, restoration, improvement and application of traditional and local knowledge, and its integration with the new knowledge from the different fields of "modern" science, in order to refine the information for the construction of productive systems and for biotechnological transformation in those in which the ecological perspective is lacking.

6. Recovery of traditional technologies and reanalysis of the present ones with the aim of offering a range of potential solutions which may be adjusted to varying ecological and cultural characteristics. This should be a participative enquiry jointly between the scientific investigators and the populations involved who know their environmental systems and are concerned in their self-management.

7. Consideration that traditional ecotechnology is adapted to local production needs, using traditional knowledge and technologies and use of native resources. This scientific and cultural store of knowledge should be assimilated to elucidate the current paradigm of sustainable development, based on the agreement on Biological Diversity, and the controversial challenge of global equality, which in turn should be based on self-management.

The Biological Diversity Convention of Rio 1992 presents a fundamental dilemma since it implicitly questions the current models of development which tend to increasing homogenisation of natural and social systems. Current management systems have been shown to be inefficient for the maintenance of biodiversity and the planning of sustainable development. In the inter-tropical regions of the American continents the greatest diversity is found in the indigenous and peasant areas where it is utilised in traditional ways. It is an urgent priority to re-evaluate their knowledge, primarily for their own benefit, and then also to provide resources shared fairly for humanity, following the objectives of the Biological Diversity Convention.

Conclusion

This survey has shown the critical importance of biodiversity to Latin American indigenous cultures, the ways which they evolved to make efficient use of it, and the great contribution so made to the development and refinement of their civilisations. It challenges the current paradigms of economic exploitation.

By implication it indicates some of the potential advantages that may accrue from the maintenance of existing biodiversity, and the salvage and restoration of that which has been partly lost, and urges development of ecotechnologies that will help to attain the objectives of the 1992 Rio Convention.

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